4.0 INSPECTION PROCEDURE

4.1 DEVELOPING AN INSPECTION PROCEDURE

The purpose of a visual inspection is to identify deficiencies that potentially affect the safety and operation of the dam. An inspector should develop a methodical procedure for inspecting a dam to ensure that all features and areas are examined and to optimize the amount of time spent in the field. First, the previous inspection reports should be reviewed to note any areas that will require special attention. However, the inspection should not be limited to the information on previous inspection reports. Second, inspection equipment should be assembled, necessary file reviews should be performed, interviews with pertinent people should be made, and site access should be arranged. Then, a plan of approach should be prepared for the visual inspection of the dam. Finally, the inspection should be documented in some manner. Additional provisions may be required, including such things as mowing the grass or clearing brush on the embankment, shutting off outlet flows, pumping down low areas with standing water, or opening gates and drawdown valves. Concrete dams may require special consideration and access provisions.

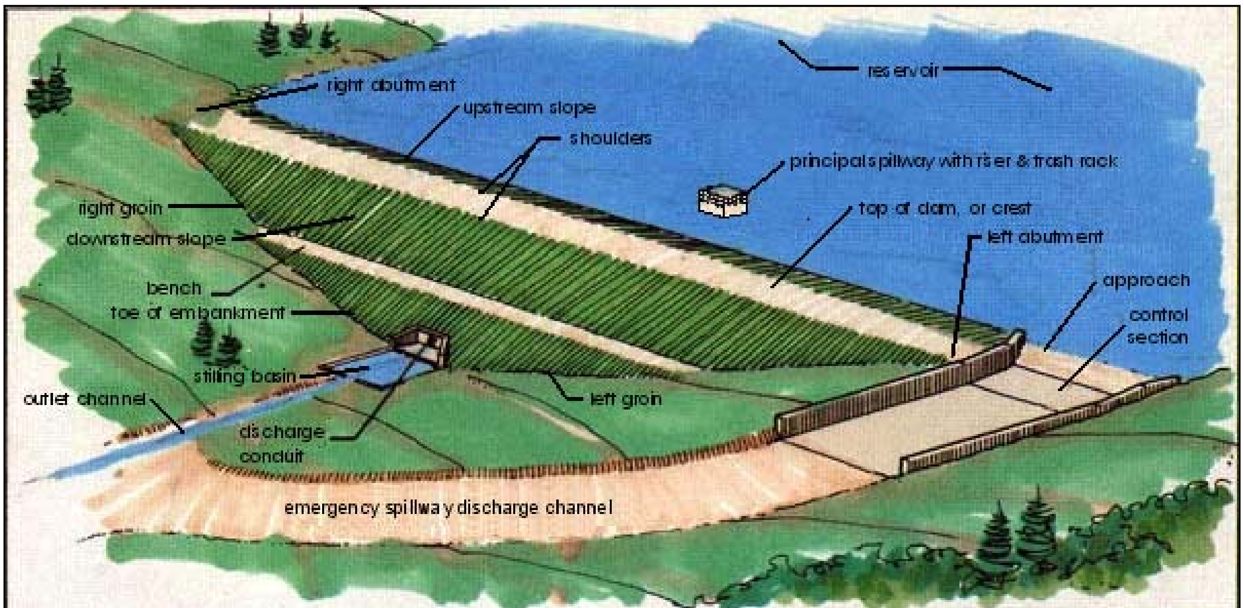

Figure 4-1 Sketch of typical dam features (the left and right sides of the embankment are referenced by looking downstream).

Figure 4-1 shows typical features that require inspection and are common on embankment dams. Dam features and descriptions should be referenced "looking downstream." For example, with the inspector standing on the embankment crest and looking downstream, the abutment on his/her right is the right abutment; the abutment on his/her left is the left abutment. Concrete dams may have similar features except they do not have an earthen embankment. Other features that are common at dams but are not shown include rock toe drains with piping, cutoff trenches, and riprap groin areas.

It is helpful to prepare an inspection route in advance to assure that every part of the dam will be observed. An inspector can take many different approaches to inspecting a dam, but the selected method should be methodical to ensure that all features are covered and to make the best use of his/her time in the field. A recommended sequence to assist with a visual inspection is presented below. This sequence generally starts at the top of the dam and proceeds downward. Sometimes it may be more effective to inspect the easiest, or most readily accessible areas first, or those areas of known problems. However, no matter where the inspector is located on the dam or spillway, he/she should stop periodically and look around for 360 degrees to observe other features from that vantage point.

(1) **Crest** - Walk across the crest from abutment to abutment, observing both upstream and downstream slopes while inspecting the crest surface.

(2) **Upstream & downstream slopes** - Walk across the slopes in a parallel or zigzag pattern along the embankment from abutment to abutment, starting with the upstream slope. (This may not be possible on concrete dams.) Particular attention should be paid to the downstream slope below the elevation of the reservoir.

(3) **Embankment-abutment contacts** - Walk the entire length of the embankment-abutment contacts (groin) on both sides of the dam, on both the upstream and downstream embankments (do in conjunction with slope inspections).

(4) **Principal Spillway** - Observe all accessible features of the principal spillway and its outlet. Inspect the inlet while performing the upstream slope inspection. Inspect the outlet after the downstream slope inspection is completed.

(5) **Emergency Spillway** - Walk along the entire length of the emergency spillway in a back and forth manner.

(6) **Abutments** - Traverse abutments in a practical manner so as to gain a general feel for the conditions, which exist along the valley sidewalls.

(7) **Outlet Works and Downstream channel** - Carefully inspect outlet works and reservoir drains that may be present. Travel the route of the stream below the dam to identify residences and property, which can be affected by dam failure.

(8) **General Areas** - Drive or walk along the perimeter of the reservoir and other upstream areas. Carefully inspect all other appurtenant works that may be present at the dam.

Additional details of inspection procedures for selected features are provided below. Following Chapters present more detail on specific dam features and problem areas, along with possible solutions to correct observed deficient conditions.

4.1.1 Inspecting Embankment Slopes

The general technique for inspecting the slopes of an embankment dam is to walk over the slopes as many times as is necessary in order to see the entire surface area clearly. From a given point on the slope, the inspector can usually see small details for a distance of 10 to 20 feet in each direction, depending on the roughness of the surface, vegetation, or other surface conditions. Therefore, to ensure that the entire surface of the dam has been covered, the inspector must repeatedly walk back and forth across the slope until he/she has clearly seen the entire area, giving greater scrutiny to the downstream slope below the pool elevation. The following patterns can be used for walking across the slope.

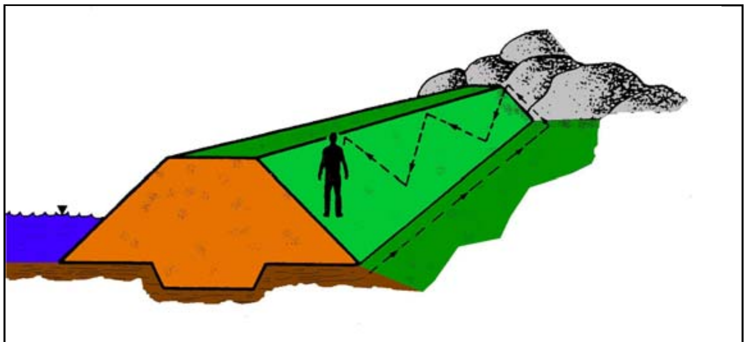

Figure 4-2 Inspecting an embankment using a zigzag approach.

Zigzag (See Figure 4-2)

A zigzag path is one recommended approach for ensuring that the inspector has completely covered the slopes and crest. It is preferable to use a zigzag path on small areas or slopes that are not too steep.

Parallel (See Figure 4-3)

A second approach is to make a series of passes parallel to the crest of the dam, moving down the slope. It is preferable to use parallel passes on larger slopes or on slopes that are very steep, since this method is less arduous.

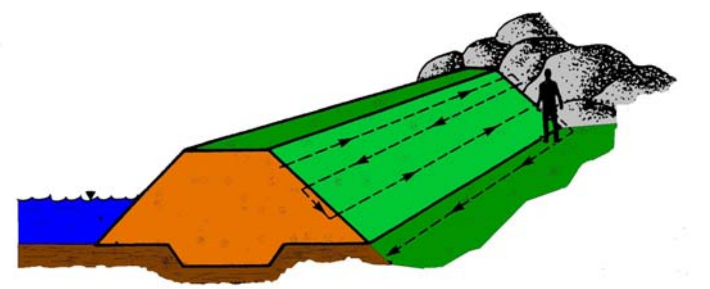

Figure 4-3 Inspecting an embankment using a parallel approach.

Both of these techniques are acceptable methods for inspecting the dam slopes and crest. Whichever technique is used, the goal is to be able to see the entire area clearly. Reaching this goal may require that you walk the area several different times for dams with high embankments. At regular intervals while walking the slope, the inspector should stop and look around for 360 degrees to check the alignment of the surface. The inspector should double check the procedure to make sure that no areas or deficiencies have been overlooked. By stopping and looking around in this fashion, the inspector should be able to view the slope from different perspectives. Seeing the slope from different perspectives sometimes reveals a deficiency that might otherwise be undetected.

In addition, viewing the slope from a distance may also reveal a number of anomalies such as distortions of the embankment surfaces and subtle changes in vegetation.

Often these types of observations are not apparent when viewing them close-up. Finally, viewing the downstream slope and toe area of the dam from a distance at a time of day when the angle of the sun is low can reveal wet areas. The wet areas become more visible due to the reflection created by the sun.

4.1.2 Inspecting Embankment Groins

The inspector should thoroughly inspect the areas where the abutments contact the embankment by walking these areas. These areas are called the groins; it's where the embankment toe intersects the existing ground surface. The groins are susceptible to surface runoff erosion, and seepage often develops along the downstream groins. The best approach to inspecting these areas is quite simple: the inspector should walk down the left (or right) groin, and then walk up the groin on the other side of the dam. The same approach is used for both upstream and downstream groins. The inspector should also check the toe of the embankment when examining the groin areas.

4.1.3 Inspecting the Crest

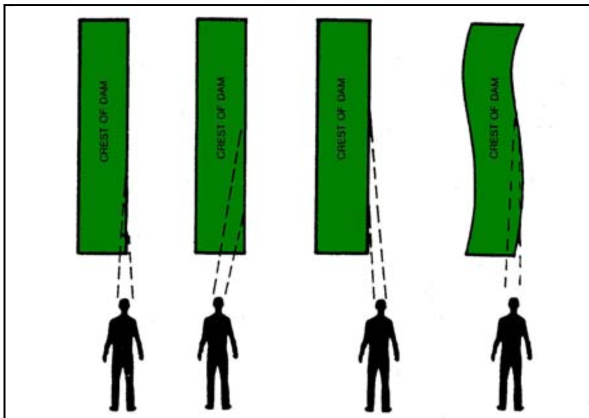

Figure 4-4 Sighting along an embankment crest.

Inspecting the crest is similar to inspecting the slopes. The inspector can use either a zigzag pattern or a parallel pattern to inspect the crest. The inspector should walk the crest as many times as necessary to cover the entire area. To ensure that no deficiencies go undetected, thorough coverage is required. The important thing is to look at every square foot of the surface area. Another helpful technique is to view the crest from different perspectives. Some deficiencies can be spotted close-up, while other deficiencies can be observed only from a distance. The sketches on the left side of Figure 4-4 show sighting along a straight embankment, while the sketches on the right side of the figure shows sighting of a bowed embankment.

Figure 4-5 Crest problems may be easily seen by sighting along a straight line on the crest.

When checking the alignment of the crest and any berms on the upstream and downstream slopes, the inspector can use a simple sighting technique to identify misalignments and other problems. The inspector should center his/her eyes along the line being viewed and move from side to side to view the line from several angles. The use of binoculars or a telephoto lens can help the inspector observe irregularities since distances are foreshortened and distortions become more apparent. The use of a reference line can also be of great assistance in sighting. Reference lines can be existing features such as guardrails, a row of posts, pavement stripes on the roadway running along the top of the dam, parapet walls, and permanent monuments that serve as horizontal or vertical control points along the surface of the dam. However, when using man-made reference lines, the inspector must check to make sure that the features have not been displaced by other causes, such as vehicles, lawn mowers, vandalism, tractors, etc. When sighting along the crest, the inspector needs to view the chosen reference line from a number of different perspectives. First sight on a direct line; then move to either side. This sighting technique is also useful for detecting a change in the uniformity of the slope. The contact between the reservoir waterline and the upstream slope should parallel the alignment of the dam axis. In other words, the reservoir waterline should be a straight line if the dam has a straight axis. To check the alignment of the waterline, the inspector should stand at one end of the dam and sight along the waterline. Misalignment of the waterline may indicate a change in the uniformity of the slope.

4.1.4 Inspecting Spillways, Outlets, and General Areas


Figure 4-6 Spillway access may make inspection difficult.

Spillways and outlets may be difficult to access, so the best approach is to walk closely along or in the structure, depending on access, and view all surface and internal areas, if possible. If conduits are large enough and appear safe, the inspector should be able to walk into the structure with a flashlight and view the inside areas. If the structure is in the water away from the shoreline or embankment, the inspector may need to use a pair of binoculars or a camera/video camera with a telephoto lens. Pictures or videos can be taken and reviewed carefully from a safe location. Boats or underwater divers may need to be employed to observe some features. Shorelines and upstream areas may be accessed on foot or by vehicle. Other appurtenant works should be closely inspected, item-by-item, from as close a distance as possible. Gates may need to be closed to make the inspection possible. Some structures may not be readily accessible and will require binoculars or video equipment to observe current conditions. Closed conduits may contain noxious gases or may lack sufficient oxygen, making them dangerous for inspectors. The inspector should always check questionable areas


Figure 4-7 Spillway with large flow.

for the presence of gases or the lack of oxygen before entering them.

4.1.5 Inspecting Concrete Dams

Figure 4-8 Dam with significant concrete spillway structures.

Although concrete dams comprise less than 1% of the total number of dams within the state, they are potentially more dangerous than embankment dams. Some embankment dams have significant concrete structures (composite dams), making inspection of them similar to inspection of both concrete and embankment dams. Basic procedures for inspection of a concrete dam are similar to those of embankment dams, except that the crest and faces of the dam may be very difficult to access. Therefore, inspector access and safety should be a primary concern on concrete dams. The faces of concrete dams are often near vertical, and the upstream slope is usually damp and slippery. Access to the downstream face, toe area, and abutments may be difficult and require special safety equipment such as safety ropes, or a boatswain's chair. Close inspection of the upstream face may also require a boatswain's chair or a boat. Without this equipment, inspection of all surfaces of the dam and abutments may not be possible. Another method of inspection that may be used consists of videotaping the dam faces from a safe point using a high power magnification on the camera. The inspector can zoom in on the surface areas and get a close up view and recording of the dam. The inspector should start filming at a discernable point, such as the top or toe of the dam face at the point of contact with the abutment. The inspector should then slowly move the camera across the face of the dam with smooth parallel movements, proceeding up or down the face after a sweep is made across the entire length of dam. Sufficient overlap of adjacent, vertical areas needs to be incorporated in the process to ensure that all areas are covered. This technique can be deployed from a boat or on the ground for the upstream and downstream faces, depending on access. The inspector may have to move along the face if the dam is relatively long. Every square foot of the dam surface can be recorded if the inspector is careful and methodical.

Figure 4-9 Dam requiring extensive concrete inspection.

The inspector should look for common ailments on concrete dams, including structural cracks, foundation or abutment weakness, deterioration due to alkali-aggregate reaction, cracks at construction joints, deterioration due to spalling, and leakage. Construction joints are provided to accommodate volumetric changes, which occur in the structure after concrete placement, and are referred to as "designed" cracks. These joints are so constructed that no bond or reinforcing, except non-bonded waterstops and dowels, extend across the joint. Outlet system inspection should be emphasized during inspection of tall concrete dams. Reading of an established monitoring network should be performed on a regular basis.

The American Concrete Institute (ACI) Report 201.1, “Guide for Making a Condition Survey of Concrete in Service,” may be useful to inspectors if concrete structures are present.

4.2 DOCUMENTING THE INSPECTION

It is important for the dam owner/operator to keep records throughout the entire life of the dam. Accurate records can better illustrate the dynamic nature of the structure and will help pinpoint problems. It is recommended that the dam owner establish a permanent file to retain inspection records, including records of actions taken to correct conditions found in such inspections. Chapter 3.0 contains details on the type and extent of records that should be kept in the project file.

4.2.1 Method of Documentation

The following methods can be used to record a visual dam inspection:

Inspection Checklist – A convenient way of compiling inspection observations is by recording them directly onto an inspection checklist. The checklist should be attached to a clipboard and carried by the dam inspector as he/she traverses the entire structure. An example of a very detailed checklist can be found in Part 3, Appendix B. It is a good idea to complete a checklist for formal technical inspections and dam maintenance inspections. A checklist will not typically be required for informal and special inspections.

Each type of inspection may have its own checklist format, and the particular format used for an inspection may be predetermined by the owner or IDNR. The benefits of using a checklist include: (1) a checklist is easy to follow and comprehensive (if properly prepared); and (2) a checklist allows the inspector to make comments or take photographs in response to a predetermined list of features and conditions at the dam.

Field Sketch – A good practice to follow along with filling out the inspection checklist is to draw a field sketch of observed conditions. The field sketch is intended to supplement the information recorded on the inspection checklists; however, it should not be used as a substitute for clear and concise inspection checklists. Problems and their location can be recorded on the field sketch. This record may be prepared for any type of inspection. Appendix D (Part 3) contains a sample field sketch.

Photographs – Inspection photographs can be vitally important. Over time, photographs serve to provide a pictorial history of the evolving characteristics of a dam. The dam owner/operator often finds them to be great money savers because they can illustrate that some observed conditions (seepage, foundation movement, etc.) have existed for many years and may have reached a state of equilibrium. With this knowledge, quick and economical remedial actions can be developed and implemented. Photographs should be dated on the back and provided with brief descriptions of the locations shown in the pictures. More details regarding the importance of photographs and other visual documentation procedures are provided in Subchapter 4.2.2.

Monitoring Data – It may become necessary to make measurements of various items during the course of a dam inspection. This may include measurements of seepage rates, spillway discharge rates, settlement, upstream and downstream water levels, and for some dams, readings from instruments such as piezometers. It is important that this data also be compiled in a systematic manner and placed in a permanent file.

Inspection Report Form – Current IDNR regulations may require the completion and submittal of an Inspection Report Form (shown in Part 3, Appendix C). This form is more likely to be required for formal technical inspections on high hazard dams only. A detailed written report incorporating the Inspection Checklist, Inspection Report Form, summary of findings, recommendations, conclusions, photographs, and other supporting data may also be prepared for formal technical inspections. The dam owner or IDNR may require this complete report periodically, especially for high hazard dams.

Notebooks – The inspector may elect to keep a field notebook that documents all of the observations and findings instead of a checklist. Notebooks can provide convenient records of dam inspections if they are formatted in a logical manner and are thorough.

Tape Recorders – Tape recorders, especially the micro-recorders, can be very convenient when it is difficult to write while the inspector is observing field conditions.

Pocket PC's and Laptop Computers – Pocket PC's (also referred to as "PDA's") and laptop computers are convenient tools for entering field inspection data in reports being prepared in the office. While laptop or notebook computers have traditionally been used for data collection, advances in Pocket PC's make them an excellent choice for the field. Pocket PC's have a variety of peripherals available and can operate for weeks between charging or battery replacement. One of the biggest advantages and potential for Pocket PC's lies in their capabilities for customization. Inspection checklist software has been developed as part of the Dam Safety Program Management Tools (DSPMT). Plug-in software

Figure 4-10 Pocket PC (PDA).

applications are available for a variety of dam specific inspection checklists, including Fill Dams, Concrete Dams, Spillways, Powerhouses, Instrumentation, etc. Using a Standard ACCESS database interface, users can easily configure the Pocket PC-based application to only present the inspection checklists utilized by the user's organization. Inspection checklist reports can be beamed directly to an IR-enabled printer; synchronized with Outlook Notes and edited in Word, or synchronized with the DSPMT Desktop. The Pocket PC's must be synchronized with a desktop system to incorporate the inspection data into a compatible inspection report.

Whatever the form of the documentation, the inspector should record his/her observations. These notes should contain information that can be used later to write an inspection report, a letter to the dam owner, an Inspection Report Form, or a memo to the project files. The inspection notes should be clear and specific, leaving absolutely nothing to memory. They should be organized in such a way that they document the present condition of each feature of the dam. In addition, any potential problem or defect that was identified during the records review should be noted and, during the inspection, its current condition should be recorded. The information typically recorded in written or tape-recorded notes should typically include:

- Inspection team participants
- Climatic conditions, especially rainfall (amounts if known), immediately prior to and at the time of the inspection
- Operating conditions such as reservoir and tailwater elevation, spillway and outlet discharge, etc
- Condition of all inspected features
- Any mechanical or electrical features
- All location, elevation, and description information
- All quantitative measurements, including instrumentation readings and surveying results (if taken)
- Safety hazards that could pose a threat to the public or project personnel
- Description of changes in the upstream and downstream areas
- Notations on any verbal information gathered, prior to or during the inspection, from operating personnel and other individuals who are not members of the inspection team

Unless the dam owner or regulatory agency has a specific policy on how notes will be taken, the inspector will need to decide whether to use written or tape-recorded methods for recording information during the inspection. Table 4-1 compares some of the advantages and disadvantages of using written and tape-recorded notes. The inspector should not rely solely on the use of tape-recorded notes. If the inspector chooses to record the majority of the inspection notes using a tape recorder, some data should also be recorded in a written format to serve as a backup in case problems are encountered with the tape-recorded notes. The combined use of written and tape-recorded notes will allow the inspector to take advantage of the good points of both methods.

Table 4-1 Comparison of Written Notes and Tape-Recorded Notes

ADVANTAGES	DISADVANTAGES
Written Notes:	**Written Notes:**
● Provide more of a permanent record.	● Takes time to write down information.
● Do not require any special equipment.	● May be difficult to read if handwriting is poor.
● Can combine sketches with written notations.	● Difficult to do when it is raining.
Tape-Recorded Notes:	**Tape-Recorded Notes:**
● Easier to say a lot and, therefore, capture more information.	● Dependent on having equipment that is in good working condition (batteries may fail, inadequate microphone may not pick up all the information, background noise)
● Easier to use when recording information	● Tapes must be transcribed. Transcriber may not be able to decipher garbled information.
● Easier to use when raining, but hard on the recorder	● Tapes could break or be erased.

4.2.2 Visual Inspection Documentation

Visual records should always be made to supplement a visual inspection. This form of recordkeeping visually illustrates any features or phenomena that the inspector observes during a dam safety inspection. The three types of visual records generally used during a dam safety inspection are: (1) photographs, (2) videotapes, and (3) annotated drawings and sketches.

Each of these three types of records can be a very effective means of recording information and can be included as part of the report.

Photographs are an excellent means of note taking, and they provide a permanent record of current conditions for future comparisons. They also provide an essential element to the written inspection report.

Figure 4-11 A picture is invaluable documentation.

It is recommended that the inspector use a 35mm camera or a digital camera (preferable) to take photographs during an inspection. These cameras typically have provisions for zooming in to magnify the features being observed. If a 35mm or digital camera is not available, an instant camera may be substituted. Using an instant camera may be helpful since the inspector can see the quality of the photographs while onsite. Also, instant photographs can be used for any immediate consultations that may be necessary back at your office. Color photographs are preferred to black-and-white prints because the color of certain deficiencies is important inspection information (e.g., changes in the color of concrete or vegetation). It is often hard to describe in words what can be captured in a photograph (see Figure 4-11).

It is helpful to make a written or tape-recorded note of the picture number, what the photograph portrays, where the photograph was taken, and the direction from which the photograph was taken and other reference information (e.g., station, elevation, etc.). Having notes about the photographs taken will help the inspector remember important information about the photographs after they are developed.

The inspector should take a large variety of photographs during each inspection, including both wide-angle shots and close-up shots of features. In addition, it may be helpful to take a series of photographs that later can be taped together to create a panoramic view of the dam and its features.

When choosing the position from which to take photographs, select the camera angle that best illustrates the feature being inspected. Whoever is reading the final inspection report should be able to clearly see and understand what the inspector is trying to illustrate about each feature. The photographs should present an exact, pictorial essay of what the inspector or other team members saw. The pictures should visually recreate the inspection so that the readers feel as if they were actually at the dam site.

There are three camera positions, which are typically used when taking photographs:

(1) A similar position as before: This allows comparison with the latest photographs with earlier ones.
(2) A different angle than before: This allows a different aspect of the feature to be viewed compared to what was photographed previously.
(3) A variety of angles: This allows the feature to be studied from a number of different directions to highlight the different surrounding characteristics.

Careful study of earlier photographs provides an excellent method of reviewing the condition of the soon-to-be-inspected dam. Such careful review of previous pictures is also important so that the inspector can take photographs of the dam features from similar perspectives.

One other factor that should be taken into consideration when choosing camera position is the quality of available light. Poor lighting obviously will result in poor pictures. Choose the camera position so as to make the most of angle and lighting. Also, watch out for shadows that will block out important details or sun in the camera lens. Figure 4-12 shows an example of picture quality when an automatic digital camera shutter speed is controlled by including the trees in the background rather than the sky; the result is a brighter picture. Figure 4-13 shows a photograph of the same scene at about the same time, but with more of the sky included in the background; the result is a shutter speed adjustment based on the sky. A darker picture is the result.


Figure 4-12 Picture with shutter speed controlled by the treeline.

It is always helpful to include recognizable objects in the photographs, providing, whenever possible, references for location and scale. For detail photographs, scale can be indicated by using a familiar object such as a pencil or notebook and placing it next to the object to be photographed. A measuring tape or ruler, if properly placed, can help show the approximate size of such aspects as a joint opening or the width of a crack.


Figure 4-13 Picture with shutter speed controlled by the skyline.

After the photographs are developed, they should be labeled with the photograph number, name of the dam, description of what is being shown in the photograph, and the date the photograph was taken. Also it may be helpful to use paste-on arrows to point to specific features, deficiencies, and conditions.

A video camera, especially with audio recording, is very effective for recording either general or specific coverage of a dam's features. Divers frequently will use a closed circuit television camera during an inspection to make a videotape. The use of closed circuit television cameras provides two benefits: it documents the inspection, and it allows for instructions to be given to the divers. Closed circuit television cameras can also be used to record the conditions inside a conduit, which cannot be accessed by the inspector. It is important to include references for location and scale in the videotape footage using the same techniques that are used for still photographs. Location references can be achieved by beginning with a wide shot of the area to be videotaped and then slowly changing to a close-up shot. Measuring devices or common objects can be used to indicate the dimensions of a feature or deficiency. If a measuring device is used, make sure it is large enough to be seen clearly on the videotape.

There are both advantages and disadvantages to documenting an inspection with videotapes. The quality of a videotape record is often not as good as that of photographs, unless it is a modern digital camera. It is difficult to compare previous photographs or old videotape footage with more recent videotape footage. This difficulty may lessen the inspector’s ability to determine what changes have occurred over time. However, the ability to combine audio and visual records is a definite advantage. The audio portion of a videotape can be an excellent means of recording the sounding of concrete structures with a hammer or bonker while photographing the location and visual appearance of the concrete surface. If videotape is used to document a dam safety inspection, the inspector should also take still photographs. Videotape is best used to supplement still photographs.

Drawings and sketches provide graphic representations of a dam feature or condition that is being evaluated during an inspection. Drawings are often helpful forms of note taking because they can document and show the location of a particular deficiency. In general, two types of drawings are useful for inspection documentation:

(1) Sketches can be drawn of major features or of a localized area of interest. It is important to record the precise location (e.g., station, elevation, monolith number, etc.) of the feature being sketched. This information will be needed if an inspection report is prepared.

(2) Existing drawings (e.g., standard sketch of the dam or reduced as-built plan or elevation view of the dam) can be used to make notes about a particular feature or to record surveying notes, measurements, or other information. A circle or an arrow can be used to highlight the features or areas of concern.

4.2.3 Writing an Inspection Report

The inspector should first gather all the information that will be used in the report. The notes developed during the initial data review and onsite inspection are two important elements. All other pertinent data and photographs that are gathered, analyzed, or reviewed should also be included.

The inspector should review the inspection notes before leaving the field or shortly thereafter, to make sure that he/she understands the notes while their observations are still fresh. They should also make sure that all noted deficiencies are described fully and documented with photographs, including the precise location and relevant quantitative measurements. Tape-recorded notes should be transcribed and the typed version should be reviewed. Often the transcriber (if other than the inspector) will not be able to understand everything the inspector has said.

The inspector should label the photographs after they have been developed (unless a digital camera is used). Next, compare the written or transcribed notes with the photographs. Comparing the photographs to the notes helps to ensure that the notes are complete and accurate. Photographs may reveal concerns that were overlooked in the notes. It is important for the inspector to label photographs while the information is fresh in his/her mind. If videotaping was employed, it is a good idea to review the film footage at this time.

It may be useful to have other inspection team members review the notes if other people were present at the inspection. The goal is to make sure that the notes are complete before report writing begins.

The next step is to evaluate all the information that has been gathered. The amount and types of information gathered may vary depending on the type of inspection conducted and inspection policies and procedures. Generally, the inspection process begins with a review of the information contained in the project file. After completing this review, the onsite inspection is conducted. After the onsite inspection is completed, the inspector may need to evaluate the information collected during the inspection using the information contained in the project file to fully understand the situation. This evaluation can also be done in the field. The results of this type of evaluation may point to another area of the dam or feature to verify or explain an observed condition. Evaluating the information gathered allows the inspector to put his/her thoughts together and develop tentative conclusions and recommendations. The inspector should think about the significance of findings before writing about them.

The inspector must integrate the findings from the data review with the observations made in the field to evaluate the information collected. Field measurements should be checked against design or as-built plans, if available. Instrument readings taken during the inspection should be checked against previous records. Comparisons should be made between previously reported deficiencies and current conditions. The status of previously recommended follow-up actions should be determined. An evaluation of both previous and current data can help identify trends and can be used to assess the seriousness of any deficiencies observed.

The depth and scope of an inspection report depends on the type of inspection that was performed. For example, an initial formal technical inspection report typically requires a greater level of detail and explanation than a maintenance or informal dam safety inspection report. In addition, an initial formal technical inspection report will be broader in scope since, by definition, it includes a comparison of design and construction data against current criteria. The greatest differences among types of inspection reports are the depth to which project features are described and the extent to which design and construction data are analyzed. The depth of a report's conclusions and recommendations also may vary depending on the type of inspection performed and the extent to which data were reviewed during the inspection. A comprehensive data review will probably enable the inspector to draw conclusions that are more thorough and to make recommendations that are more extensive. Although the depth and scope of inspection reports may differ, a comprehensive description of the conditions observed during the onsite inspection should be included in all reports.

The format of the report is generally dictated by the type of inspection performed (i.e., formal technical, maintenance, informal, special) and will determine how the content of the report is to be organized. The formal technical inspection report will be the most comprehensive, while a special or informal inspection report may be very brief, and may consist of only a letter with attached field notes and photographs. Appendix E in Part 3 contains a sample outline of a detailed inspection report that should be included with formal technical inspections.

A formal technical inspection report should include the following major parts:

- Report Introduction (Executive Summary) - provides background information about the dam and the inspection that was conducted.
- Body of the Report - describes the current conditions or concerns in detail.
- Conclusions - presents the inspector's judgment regarding the conditions

observed. All factors are taken into consideration. Conclusions should be made on all features, even if satisfactory.

- Recommendations - describes what actions should be taken as a result of the inspection (e.g., further investigation, analysis, repair, monitoring, etc.). Each recommendation should be supported by a conclusion.
- Attachments (Appendices) - provides additional information that supports or supplements the information presented in the body of the report; includes photographs, sketches, instrumentation data, field inspection checklists, and IDNR Inspection Report Form.
- If an inspector changes the safety rating of the dam or one of its components from prior ratings, substantive documentation should be provided to support the change.

Depending on current regulatory requirements, a copy of the detailed inspection report may need to be submitted to IDNR, along with an IDNR Inspection Report Form.

4.3 WHAT TO LOOK FOR

4.3.1 Overview

Figure 4-14 Serious slide on an embankment dam.

The features the inspector should examine depend on the type of inspection and the type of dam (embankment, concrete, timber). A formal technical inspection will involve visual inspection of all dam features and general features around the dam. These features typically include embankment crest and slopes, principal and emergency spillways, outlets and drains, and miscellaneous features in the watershed. A maintenance inspection should also include inspection of all the dam features.

Informal and special inspections usually focus on specific features and do not necessarily cover all of the dam features. However, it is recommended that informal inspections are performed frequently and cover as much of the dam and its structures as possible. The need to view site-specific features should be considered in preparing for the inspection.

Typically, the individual features of a dam will be visually examined and physically measured to determine the condition and to verify conformance with design or as-built plans. If data and plans are not available, the examination process will determine the characteristics, locations, and dimensions of the individual features. Modifications of features will be revealed during the examination. The relationship between the levels of the reservoir to the dam and its appurtenances on the day of the inspection is significant. Some features may not be visible at higher water levels. Seepage areas or other potential problems may not be readily apparent during an inspection when the reservoir level is low. Generally, all instrumentation systems should be inspected. The inspector should evaluate the condition of monitoring devices and collect data when appropriate for inspection purposes.

Embankment Dams (earthfill, rockfill)

Upstream slope
Downstream slope
Left and right abutments
Crest
Upstream & downstream groins
Downstream toe
Internal drainage outlets
Riprap & other slope protection

Concrete Dams (arch, gravity, roller-compacted)

Upstream face
Downstream face
Crest
Left and right abutments
Downstream toe
Galleries
Sluiceways and controls
Relief drains

Spillways (earth, rock, structural)

Approach channel
Inlets and control sections
Discharge conduit
Discharge channel
Outlet structures and stilling basins
Joints
Control features (gates, stoplogs, flash boards)
Trash racks and debris control
Drains (pressure relief)
Side slopes
Sidewalls
Erosion protection (riprap, vegetation, concrete, gabions)

Outlets & Reservoir Drains

Inlet structures
Discharge conduit
Discharge channel
Outlet structures and stilling basins
Joints
Control features (gates, stoplogs, valves, bulkheads, hoists)
Trash racks and debris control
Drains (pressure relief)
Erosion protection (riprap, vegetation, concrete, gabions)
Access

General Areas

Submerged areas
Mechanical and electrical systems (cables, generators, winches, etc.)
Watershed and tributary stream channels
Access
Slope reinforcing and retaining structures
Shoreline and hillsides
Instrumentation
Downstream hazard
Upstream development
Downstream channel obstructions
Reservoir area
Emergency power systems
Hydropower facilities

Timber Dams

All wood or timber features
Ballast
Abutment walls
Downstream erosion control

Table 4-2 Typical Features that may Require Visual Inspection

The geologic features of any site such as abutments, foundations, and subsurface materials, are normally covered and cannot be directly examined. In order to evaluate geologic features, it is important to examine areas adjacent to both the dam and the reservoir for conditions, which may indicate a problem. A complete review of all available geotechnical information for any dam is necessary to perform the inspection properly. A geophysical investigation may be required if the subsurface conditions warrant further inspection.

When individual features of a dam are examined, the inspector should look for typical conditions that indicate a problem may exist. The significance of these conditions will be discussed in the following Chapters. Visual observations may identify conditions of a serious nature that require immediate repairs, or other conditions that may indicate a minor problem that require only routine maintenance or monitoring. Findings from prior inspections can be used to identify conditions that existed previously. These findings are useful for comparison of the dam in its present state to denote any changes in the condition and its assessment.

Conditions to look for and the level to which the dam features can be examined will depend on many factors. The type of inspection will dictate the detail to which the conditions need to be evaluated. Access, seasonal and weather conditions, impoundment levels, and equipment availability may limit the evaluation. A cursory inspection may be made to check for changes in previously identified conditions. Specific conditions should be looked for following an extreme event such as an earthquake or major hydrologic event. The following paragraphs summarize the general types of conditions to look for.

4.3.2 Embankment Dams

Embankment dams are the most common type of dams in Indiana. Typical types of embankment dams include earthfill dams, homogeneous earthfill dams, rockfill dams, and zoned embankment dams. Common problems to look for on the various dam features are summarized below.

Upstream Slope - animal burrows, beaching, cracks, debris, depressions, erosion, paths and ruts, sinkholes, slides and scarps, sloughs, utilities, telephone cables, electric cables, and vegetation.

Downstream Slope - seepage, depressions, erosion, paths and ruts, sinkholes, slides and scarps, sloughs, animal burrows, buried pipes (water, sewer, gas), cracks, utilities, telephone cables, electric cables, and vegetation.

Left and Right Abutments - animal burrows, cracks, depressions, erosion, geologic features, paths and ruts, seepage, sinkholes, slides and scarps, sloughs, utilities, telephone cables, electric cables, and vegetation.

Crest - alignment, animal burrows, buried pipes (water, sewer, gas), cracks, displacements, paths and ruts, settlement, utilities, telephone cables, electric cables, and vegetation.

Upstream and Downstream Groins - animal burrows, erosion, paths and ruts, seepage, sinkholes, undermining, and vegetation.

Downstream Toe - animal burrows, cracks, depressions, erosion, paths and ruts, seepage and boils, sinkholes, sloughs, undermining, and vegetation.

Internal Drainage Outlets - cloudy drainage, metal corrosion, flow rate, obstructions, structural damage.

Riprap and Other Slope Protection - beaching, coverage, deterioration, riprap displacements, undermining, weathering, exposed, or torn geotextile.

4.3.3 Concrete Dams

There are only a few concrete dams in Indiana. Concrete dams can be more hazardous to inspect than embankment dams due to the usual steep and wet faces. Typical concrete dams include arch dams, gravity dams, and roller-compacted dams. Common problems to look for on the various concrete dam features are summarized below.

Upstream Face - alignment, concrete condition (cracks, deterioration, spalling, and weathering), displacements, joint separation and deterioration, structural damage.

Downstream Face - alignment, concrete condition (cracks, deterioration, spalling, and weathering), displacements, joint separation/deterioration, seepage, structural damage.

Left and Right Abutments - cracks, displacements, erosion, geologic features, seepage, vegetation, weathering (rock).

Downstream Toe - cracks, seepage, undermining.

Galleries - cracks, displacements, efflorescence, joint separation, seepage.

Relief Drains - cloudy drainage, flow rate, obstructions.

Sluiceways and Controls - (See Spillway System and Outlets)

4.3.4 Spillway System (Earth, Rock, Structural)

All dams should have spillways to allow for the discharge of stormwater inflows. Spillways can be constructed in earth and lined with vegetation, geotextiles, or rock, or they can be constructed of structural materials such as concrete or concrete blocks. Spillways constructed in earth are open spillways. Spillways constructed with concrete materials can be open (open to the air, similar to a channel), or they can be closed spillways consisting of a drop inlet, or riser, connected to a discharge conduit. Closed spillways can also consist of a conduit placed through the embankment without the use of a riser. Closed spillways should always use a trash rack. Common problems to look for on spillway components are summarized below.

Approach Channel - alignment, obstructions, paths and ruts, sedimentation and siltation, vegetation, restrictive areas not designed as a control section.

Inlets and Control Sections - alignment, concrete condition (cracks, deterioration, erosion, spalling, weathering), deterioration (other materials), cracks, joint separation and deterioration, metal corrosion, obstructions, paths and ruts, settlement, spalling (rock), structural damage, vegetation.

Discharge Conduit - alignment, cavitation, concrete condition (cracks, deterioration, erosion, spalling), joint separation and deterioration, leakage, metal corrosion, obstructions, paths and ruts, seepage, settlement, structural damage, undermining, abrasion damage to the floor and walls, vegetation.

Discharge Channel - alignment, erosion, obstructions, paths and ruts, seepage and boils, vegetation, restrictive areas not designed as a control section.

Outlet Structures and Stilling Basins - alignment, concrete condition (cracks, deterioration, erosion, spalling, and weathering), debris, displacements, erosion, obstructions, seepage, structural damage, undermining, abrasion damage to the floor and walls.

Joints - alignment, concrete deterioration, metal corrosion, seepage, separation, damaged or missing seals.

Control Features - emergency operation, leakage, metal corrosion, operation, structural damage, timber, or wood deterioration.

Trash Racks and Debris Control - alignment, debris, metal corrosion, opening sizes, operation.

Drains (Pressure Relief) - cloudy drainage, flow rate, obstructions.

Side Slopes - geologic features, slides and scarps, sloughs, vegetation and vegetal cover, weathering (rock).

Sidewalls - alignment, concrete condition (cracks, deterioration, erosion, spalling, weathering), displacements, seepage, structural damage.

Erosion Protection - coverage, deterioration, structural damage, weathering.

4.3.5 Outlets and Reservoir Drains

Outlets and drains are used to drawdown the reservoir level in times of emergencies or when the need arises to lower the water for any reason. Outlet facilities are usually submerged or buried and are difficult to inspect. Common problems to look for on outlet components are summarized below.

Inlet Structures - alignment, concrete condition (cracks, deterioration, erosion, spalling, weathering), displacements, metal corrosion, obstructions, settlement, structural damage, operability (does it perform as designed?).

Discharge Conduit - alignment, concrete condition (cavitation, cracks, deterioration, erosion, spalling), displacements, joint deterioration and separation, metal corrosion, obstructions, seepage, settlement, structural damage.

Discharge Channel - alignment, erosion, obstructions, seepage and boils, vegetation.

Outlet Structures and Stilling Basins - alignment, concrete condition (cracks, deterioration, erosion, spalling, weathering), debris, displacements, obstructions, seepage, structural damage, undermining, operability (performing as designed).

Joints - alignment, concrete deterioration, metal corrosion, seepage, separation, voids, damaged or missing seals.

Control Features - emergency operation, leakage, metal corrosion, operation (performance and protection from unauthorized persons), structural damage, timber, or wood deterioration.

Trash Racks and Debris Control - alignment, debris, metal corrosion, opening sizes, operation.

Drains (Pressure Relief) - cloudy drainage, flow rate, obstructions.

Erosion Protection (discharge channel) - deterioration, structural damage, weathering.

Access - Condition of roadways, obstructions (potential), personnel safety (ladders, walkways, bridges, handrails), protection from unauthorized persons.

Emergency Systems - operation, location, and access.

4.3.6 General Areas

General areas basically include all other areas not listed above, such as upstream watershed areas, downstream channels and watershed areas, access roads, shorelines, and other appurtenant works and structures. Common problems to look for in general areas are summarized below.

Submerged Areas - debris, erosion and scour, structural damage, undermining.

Mechanical and Electrical Systems - backup systems, corrosion, deterioration, general condition, leakage (gates, valves, bulkheads), operation.

Watershed and Tributary Stream Channels - channel dimensions, diversions, erosion, land use (future conditions), obstructions, sedimentation, vegetation.

Downstream Channel Obstructions - bridge crossings, channel dimensions, erosion (slide potential), obstructions, sedimentation, vegetation.

Reservoir Area - bridge crossings, development (in high water zones), pipelines, subsurface mining, sedimentation, topography (areas below maximum pool elevation), vegetation, water quality, whirlpools, boat moorings or other features that may break loose and clog the spillway.

Emergency Power Systems - operation and access, backup systems.

Shoreline and Hillsides - beaching, erosion, depressions, land use, landslides, vegetation.

Instrumentation - collect data as required and check condition.

Downstream Hazard - present and future development.

Access - road conditions, gates and fences, downstream channel crossings.

Hydropower Facilities - diversion tunnels and by-pass systems, intake structures, operation, penstocks, release structures (tailrace), structural damage.

Slope Reinforcing and Retaining Structures - alignment, anchors, concrete condition (cracks, deterioration, spalling, weathering), displacements, joint separation and deterioration, structural damage.

4.3.7 Timber Dams

Timber dams are rare and were typically constructed in the past at mills. Timber is generally a poor construction material for dam embankments due to the tendency for it to rot. Common problems to look for on timber dam components are summarized below.

All Wood or Timber Features - alignment, displacements, undermining, wood deterioration and preservation.

Ballast - depressions, deterioration.

Abutment Walls - alignment, concrete condition (cracks, deterioration, spalling, weathering), displacements, joint separation and deterioration, seepage, structural damage.

Downstream Erosion Control - deterioration, structural damage, weathering.